# OPERATOR'S MANUAL

1600-HP. ALL-SERVICE
DIESEL-ELECTRIC LOCOMOTIVES

BALDWIN-LIMA-HAMILTON CORPORATION
PHILADELPHIA, PA.

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# O P E R A T O R ' S  M A N U A L

NO. AS-103

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1600 H.P. ALL-SERVICE

DIESEL-ELECTRIC LOCOMOTIVES

WITH

ELECTRIC THROTTLE

DYNAMIC BRAKING AND

MULTIPLE UNIT CONTROL FOR TRAILING

TRANSITION-TYPE LOCOMOTIVES

* * * *

BALDWIN-LIMA-HAMILTON CORPORATION
PHILADELPHIA, PENNA.

SEPTEMBER 22, 1953

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# P R E F A C E

This manual describes normal operation of B.L.H. 1600 H.P. All-Service locomotives equipped with an electric throttle and multiple unit controls.

The standard locomotive may be modified to include dynamic braking or to meet varying requirements in connection with other locomotives with which it may operate. Instruction must therefore cover more than one type of equipment in certain instances such as transition (manual or automatic), air brakes (6-SL or 24-RL), traction motor cut-out (rotary switch or toggle switches), etc. In general, operators can disregard paragraphs pertaining to equipment not on their locomotive. When the locomotive is designed to operate in multiple with other types of locomotives, some controls which are not necessary on B.L.H. units alone must then be handled in accord with instructions furnished for the other trailing unit. Crews should determine what other types of locomotive will operate satisfactorily with this locomotive before connecting them in multiple.

This book does not give maintenance information which is furnished in separate publications for the diesel engine and auxiliary equipment.

## GENERAL SPECIFICATIONS - ALL-SERVICE UNITS

| BLH Classification | AS-16 | AS-416 | AS-616 |
|---|---|---|---|
| Wheel Arrangement | 0-4-4-0 | 0-6-6-0 | 0-6-6-0 |
| Wheel Diameter | 42" | 42" | 42" |
| Driving Motors | 4 | 4 | 6 |
| Gear Ratio | 15:63* | 15:63 | 15:63 |
| Max. Speed - MPH | 70* | 65 | 60 |
| Total Approx. Wgt. Lb., in Working Order | 242,000 | 255,000 | 325,000 |
| Capacity - Gallons | | | |
| Fuel Oil | 900 | 900 | 1900 |
| Lubricating Oil | 200 | 200 | 200 |
| Cooling Water | 300 | 300 | 300 |
| Sand Capacity, Cu.Ft. | 30 | 30 | 30 |
| Diesel Engine | One, Supercharged, 8 Cyl. | | |

*Also available in 17:62 Gear Ratio, 80 MPH Speed.

## MECHANICAL INTERLOCKS ON THE CONTROLLER

1. The reverse lever cannot be operated if transition is in "2", "3" or Braking, or if the throttle is in any position but "idle".

2. Reverse lever cannot be removed unless the transition lever is "off". Transition is locked in "off" when reverse lever is removed.

3. The throttle is confined to "idle" or "stop" positions if transition lever is in "off".

4. Transition lever cannot be moved from 2 to 3 or 3 to 2 unless throttle is in 6 or lower.

5. The transition lever cannot be moved into "2", "3" or Braking if the reverse lever is "off".



## GENERAL DESCRIPTION

The All-Service locomotive is designed for flexible operation in either general switching or road service. An 8-cylinder, supercharged diesel engine drives a direct connected main generator which delivers electric power to traction motors geared to the driving axles. Load regulation is provided by a type PG Woodward Governor which functions through valves in the throttle control system. This automatic determination of available power does not require judgment by the engineer. The throttle controls speed and power with maximum simplicity, leaving the engineer free to handle other controls and observe gauges, signals and road conditions.

Crews should be familiar with the cab and electrical equipment cabinet, and with the operation or resetting of protective equipment such as the overspeed stop, emergency fuel cut-off valve, and breakers and relays, which are described in the Electrical Section.

An auxiliary generator charges the battery, energizes the control circuits, and supplies the exciter 4-pole field at a regulated constant voltage. The exciter furnishes main generator field excitation. The battery starts the engine and provides standby lighting service. The engine is started from the cab by pressing the start buttons which control the starting circuit, connecting the battery at the main generator which acts as a motor while cranking the engine. Traction motor blowers are engine driven; radiator fans are motor driven. Locomotive has standard air brakes with engine driven compressor; governor is set to maintain a pressure of 125 to 140 psi. A

pneumatic control system, operating in conjunction with the throttle and electrical equipment, functions at a pressure of 70 psi. It will require no attention during normal operation if the gauges indicate the proper reading.

## LOCOMOTIVE CAB

Most of the manual controls for the locomotive are located in the cab. The automatic brake valve and independent brake valve are standard air braking equipment with which crews are familiar. Various gauges are conveniently located in front of the engineer. Normal gauge readings are stated on page 13.

Locomotive speed and power are controlled by the throttle and transition selector, and the direction of travel is controlled by the reverse lever. These controls are on the master controller at the engineer's position. See "Interlocks", page ii.

The throttle has ten positions, "stop", "idle", and eight running positions. Each position energizes various combinations of magnet valves in the engine governor to determine power output. It is mechanically interlocked to prevent unintentional movement into the "stop" position, which can be entered only after pressing a button in the handle of the throttle.

The reverse lever has "off", "forward" and "reverse" positions, which control magnet valves in the main reverser. These valves respond to the setting of the reverse lever in a way that causes the reverser to take a corresponding position, thereby changing the power connections for the respective directions of travel.



A transition selector above the throttle controls manual transition when operating in multiple with other types of locomotives, which are not equipped with automatic transition. It has six positions, "off", 1, 2, 3, 4, and Braking. The Baldwin All-Service locomotive requires no manual control for transition or field shunting, and the selector is therefore handled in the same manner as required on the locomotives to which it is connected.

The various switches are marked, and their operation is obvious unless described below. The first four switches are located at the control stand.

Control Switch - Must be closed except when locomotive is shut down. When one or more locomotives are connected for multiple operation, the control wire is train-lined to all units. Control switch on the controlling unit only should be closed.

Generator Field - This switch must be closed, in the controlling unit only, to energize the main generator field contactors and related circuits. It must be closed to obtain proper field excitation (and power) in either (a) one unit operating alone, or (b) both units of two locomotives connected for multiple unit operation.

Fuel Pump - This switch must be closed on the controlling unit only in order to run the fuel pumps. It energizes a fuel pump contactor in all units in multiple which in turn closes the circuit supplying the fuel pump motors.

Multiple Unit Shut-Down - Closing this switch will stop all engines on all units connected in multiple.

Engine Control Switch - Must be in the "engine idle" or "power on" position in order to run the fuel pump or crank and run the engine.

Auxiliary Generator Switches - These are breaker-type switches in the equipment cabinet, and are kept closed to supply power to the control circuits and exciter 4-pole field, and charge the battery. They are kept closed on all units in multiple operation.

Fan Control Switch - Feeds fan control circuit. See "Cooling Water System". This switch has three positions: "Off" - Fans stop; "Auto" - Fan speed automatically regulated; "On" - Fans operate at intermediate speed only. Use this switch if automatic control fails.

Ground Relay Reset Button - Used to reset ground relay in high voltage power circuit.

Indicator Lights are plainly marked and show whether the related safety device has tripped. An alarm bell rings at the same time. See page 29.

Deadman Pedal, when installed, is a safety device which must be depressed at all times when the locomotive is in operation. This is a safeguard against the incapacitation or negligence of the operator. A release of the deadman pedal causes a warning whistle to sound for approximately 5 seconds after which the brakes are automatically applied and the engines brought to idling speed. If the deadman pedal is depressed within the warning period, however no action takes place.



## ELECTRICAL EQUIPMENT CABINET

Most of the electrical equipment is located in a cabinet situated between the cab and the diesel engine.

Operating personnel should observe the safety instructions given in the note at the bottom of page 6.

The following manually controlled items of equipment in the cabinet are in the low voltage control circuit, and crews should be familiar with their use.

Battery Switch - Must be closed to energize all control circuits, and all lighting circuits, except the cab and cabinet lights which are fed directly from the battery.

Traction Motor Cut-Out Switches - Use in event of a traction motor failure. On locomotives without dynamic braking, two on-off switches are installed, each switch controlling one set of traction motors. On locomotives equipped for dynamic braking, a 4-position rotary switch is installed. Nameplates indicate which motors are out of service. See page 14.

Ground Relay Cut-Out Switch - For use in cutting out ground relay until a ground in the high power voltage circuit can be rectified.

Circuit Breakers - Safety device to protect electrical equipment in a circuit from overload or excess current. See page 42.

A dynamic braking unit selector switch in the equipment cabinet is set for the number of units connected in multiple in order to obtain proper generator field excitation. In dynamic braking set the switch to "1" when operating alone, to "2" when controlling two units, "3" when controlling three units and "4" when four units are connected in multiple. A field loop circuit puts fields of all connected units in series with each other, and the setting of this switch adjusts the circuit resistance to obtain identical field current for any of the possible operating connections. The switch must be set in the controlling units only, because it is not in the field loop circuit on trailing units. NOTE: DYNAMIC BRAKING CANNOT BE USED WHEN OPERATING IN MULTIPLE WITH ALCO LOCOMOTIVES.

A voltage regulator holds the auxiliary generator voltage constant over the normal speed range of the diesel engine. It is set slightly above battery voltage so the battery will receive a charge if necessary. It is important that operators do not attempt to adjust or repair the voltage regulator or change relay settings.

The principal items of electrical control equipment not mounted in the electrical cabinet are the shutter valves on the radiator compartment bulkhead, a hot water switch and temperature control switches. The heavy duty cam switch (on dynamically braked locomotives) is mounted on the rear (engine side) of the cabinet.

SAFETY NOTE: The main power circuits operate at 600 volts or more. Cabinet doors should not be opened except by authorized and qualified personnel. When doors are open, it is important that adequate safety rules be observed.



## LOCOMOTIVE OPERATION

I. PRELIMINARY CHECK:

A. Check the following supplies:

1. Fuel oil.
2. Engine crankcase and governor oil.
3. Air compressor crankcase oil.
4. Engine cooling water.
5. Sand.

B. Check for any leaks in fuel, water and lubricating oil piping.

C. Light lamps, if required, by closing the corresponding switches on the control stand. On most locomotives, no lights but the cab and cabinet lights will burn until the battery switch in the equipment cabinet is closed.

D. Inspect the engine, generator and other machinery for rags, tools, etc. that may have been accidentally left near the moving parts.

II. STARTING THE DIESEL ENGINE

A. Close battery switch. Check that both auxiliary generator switches in the cabinet are closed.

B. Put the throttle in the "idle position.

C. Insert reverse lever. Leave it in the "off" position. The transition selector should be in the "off" position.

D. Set engine control switch in the "engine idle" position.

E. Close the control switch, and fuel pump switch at the control stand on the controlling unit. Each of these circuits are train-lined to trailing units in multiple so that these switches need not be closed on trailing units.

The fuel supply pump should start, and a pressure of 20 to 25 pounds should be indicated on the fuel oil pressure gauges. If pump does not run, check control and lighting breaker in cabinet. If pump runs and no pressure is indicated, check fuel supply or emergency fuel cut-off valve at the fuel tank and reset if necessary.

F. Press No. 1 "engine start" button. If necessary to crank faster, press No. 2 "engine start" button, keeping No. 1 button in. Press firmly until the engine fires. If engine does not fire, do not hold button in more than 10 seconds because continued cranking will run down the battery. If the engine does not rotate, release the button immediately.

## III. PUMPING AIR

A. As the engine runs, the air compressor will pump air into the main reservoirs. Check the main reservoir air pressure to be sure the compressor stops pumping when the governor cut-out setting of 140 lbs. is reached.



B. Air may be pumped at a higher rate, if desired, by bringing the engine speed above idling as follows:

1. Place reverse lever in "off" position and transition in "1". Open generator field switch at the control stand.

2. Increase the throttle setting, speeding up the engine and the compressor, until the pumping rate desired is reached. Never move the throttle more than 3/4 open for this purpose.

3. Return the throttle to the "idle" position when the air pressure gauge registers the required pressure.

C. Be sure the air compressor resumes pumping when the main reservoir pressure drops to the lower governor setting of 125 lbs.

D. Check the control air pressure on the gauge in the cab. It should be 70 lbs.

## IV. MOVING THE LOCOMOTIVE

A. With the throttle in the "idle" position and the reverser "off", make sure that:

1. The traction motor cut-out switch in the control cabinet is set properly.

2. The traction motor blowers are operating properly.

3. The radiator fans are operating. They are electrically driven. The fan switch should be in "auto" position.

4. The automatic and independent air brakes apply and release properly.

5. Engine control switch is in the "power on" position.

B. Close the generator field switch, if open.

C. Move the reverse lever to the "forward" position or the "reverse" position, according to the direction the locomotive is to travel.

D. Place transition selector in No. 1 position. Release brakes and advance the throttle. If the train is not too heavy nor the grade severe, the locomotive will move. If the locomotive does not move, return the throttle to "idle" immediately.

E. When the meter registers current and the train starts to move, advance the throttle till the desired acceleration is attained. Set the transition selector as required on any trailing locomotive with manual transition (i.e., position "1" below approximately 17 mph, position "2" between 17 and 23 mph, position "3" between 23 and 49 mph, and position "4" at higher speeds. However, on a Baldwin operating alone, or in multiple with another Baldwin, the selector lever may be



left in position "4" all the time).

F. Avoid slipping the wheels, if possible. If the wheels should slip, the wheel slip buzzer will sound and the diesel engine speed will automatically decrease until the slipping stops. If wheels slip again, retard the throttle until wheel slip stops.

G. Sanding is seldom necessary, due to the even starting torque of the diesel electric locomotive. Depressing the sanding bail on the brake pedestal will sand only the leading wheels of each truck. Application is automatically limited to the direction of travel, because the electrically operated sanding valves are fed through interlocks on the reverser.

CAUTION: Do not apply sand while the wheels are slipping. Always use sand sparingly.

H. As train speed increases the traction motor fields are weakened by shunting the field windings with resistance, rendering it possible to run at higher speeds. Amperage increases at time of shunting.

I. ELECTRICAL LOAD LIMITS. Overheating due to excessive loads can result in serious damage to electrical equipment which may not be apparent immediately but can cause failure later. Electrical apparatus will safely carry an overload for a limited time if maximum allowable temperature has not been reached.

A table of allowable load limits under full cooling (i.e., full engine speed if blowers are engine driven) is posted in front of the engineer. OPERATORS SHOULD ALWAYS KEEP WITHIN PROPER LIMITS.

The posted ratings are subject to the following restrictions:

1. Starting rating must not be used for more than 3 minutes. This starting period must not follow continuous duty, but may be used only after a cooling period of at least 15 minutes.

2. Short time ratings are not cumulative. Any one short time rating may follow continuous duty, but 30 minutes of operation at continuous rating or less must intervene between use of short time ratings.

The crew must pay careful attention to load limits in any abnormal operation, as for example, when a traction motor is cut out, or when motors are overloaded at less than full engine speed (full throttle). The latter condition may exist in humping, or with heavy tonnage upgrade under speed restrictions. Overload capacity is considerably reduced when blowers operate at less than full engine speed.

V. INSPECTIONS DURING OPERATION

A. Check the gauges frequently, and



investigate any great deviation from normal.

1. Lube Oil Pressure - Normal 50 lbs. to 55 lbs. when engine is operating at rated speed, and normal operating temperatures have been reached.

2. Lube Oil Pressure, Turbocharger - Normal 22 lbs. to 25 lbs. at full speed.

3. Fuel Oil Pressure - Normal 20 to 25 lbs.

4. Water Temperature - About 150° to 190° F.

5. Control Air Pressure - Normal 70 lbs.

B. Rotate the handles on the metal edge lubricating oil strainer two full turns every day. This strainer is located in the radiator compartment.

C. Check the cooling water level on the sight gauge at expansion tank every 8 hours. Level must be maintained so that water is visible at all times.

D. Check the lubricating oil level once every 8 hours with the engine stopped. It must be maintained above the "low" mark on the bayonet gauge.

E. Drain the main air reservoirs once every 8 hours.

F. Check battery ammeter. It should never show a discharge when engine

is running. Report such condition to maintainer. The high charging rate after starting the engine will decrease and approach zero as the battery becomes fully charged.

G. Make periodic visual inspection of equipment under the locomotive for loose or dragging parts. Report unusual noises or odors to maintainer.

## VI. CUTTING OUT A TRACTION MOTOR

A. Should a failure occur in a traction motor it may be taken out of service by turning the traction motor cut-out switch. All motors in series are cut out together. Do not change this switch while power is on.

1. Return the throttle to "idle" position and put the reverse lever in "off" position.

2. Turn the traction motor cut-out switch to the position designated on the nameplate for opening the motor circuits.

B. When locomotive is not equipped for dynamic braking the load ammeter is connected in the generator circuit. When operating with a set of traction motors cut out, do not exceed 1/2 of the current listed under load limits. Current is automatically reduced without corresponding reduction in throttle setting.

C. When locomotive is equipped for dynamic braking the load ammeter is connected to register the flow of



current through motors 1 and 2, consequently there will be no ammeter reading if this pair is cut out, even though power is being supplied to the other motors. The ammeter reading will not be affected if motors 3 and 4 are cut out.

NOTE: Do not try to rerail a locomotive under its own power, as serious damage may result to the traction motor from spinning the wheels. However, if only one pair of wheels is derailed it is possible to rerail the locomotive under its own power by cutting out the motor driving the derailed wheels.

## VII. STOPPING THE LOCOMOTIVE

A. Move the throttle to the "idle" position. When the locomotives with manual transition are connected in multiple use the transition lever in the same manner as required on the trailing locomotive. (i.e., as speed decreases, the transition selector should be set in the same position for various speeds, as observed in Section IV, when speed is increasing).

B. Apply the brakes.

1. Do not use the independent air brake to stop a heavy train; use the automatic brake.

2. Never apply brakes unless the throttle is in "idle" position, as this may result in an overload.

C. If the locomotive is to be left standing temporarily:

1. Put the reverser lever in the "off" position.

2. Apply the hand brake.

## VIII. REVERSING THE LOCOMOTIVE

A. Bring the locomotive to a full stop as just outlined in Section VII.

B. Move the reverse lever for operation in the opposite direction.

C. Release the brakes.

D. Resume operation by advancing the throttle and changing transition selector in the usual manner.

CAUTION: Never move the reverse lever while the locomotive is in motion as this may result in serious damage to the electrical equipment.

## IX. SHUTTING DOWN THE LOCOMOTIVE

A. Let the engine idle for at least 10 minutes.

B. Stop the engine by pressing the button in the throttle handle and moving the throttle to the "stop" position. An alternate method is to press the multiple unit shutdown button.

C. Open the control switch, generator field switch and fuel pump switch.

D. Open the main battery switch.



E. Set the hand brake and release the air brakes.

F. Turn off all lights.

G. Remove reverse lever.

H. If the locomotive will be exposed to freezing temperatures, take the necessary precautions. See page 37.

## X. SHUTTING DOWN ENGINE IN AN EMERGENCY

A. Push multiple unit shutdown push button switch until engine stops, if all engines in multiple are to be stopped. Turning an engine control switch will stop the engine on one unit only.

B. In case of fire or accident creating a hazard to fuel lines, pull the red emergency fuel cut-off valve handle in the right rear corner of the cab, or on the outside of the locomotive on the right side under the cab.

It will be necessary to reset the fuel cut-off valve manually before starting the engine. Put the throttle in the "idle" position, and put the reverse lever in the "off" position before restarting.

## XI. TO ISOLATE POWER UNIT

A. To isolate a unit, place the Engine Control in the "idle" position. This will disconnect the power circuit and bring the engine to idling speed regardless of throttle setting. An isolated unit will

pump air, charge the battery, and operate the engine water system to prevent freezing in cold weather. In multiple unit operation, any unit may be isolated without affecting the control of power output of the other units.

## XII. PUSHER OR DOUBLE HEADING SERVICE

A. In such service, power is controlled on each locomotive in the usual manner, but service brakes are controlled by the leading locomotive only. However, the non-controlling locomotive can release its own brakes only, to avoid sliding or overheating the wheels. Conform to standard practice of the railroad in your area.

B. On a pusher locomotive with 6-SL brake equipment, close the brake valve 2-position cut-out cock and place both brake valve handles in Running position. With 24-RL brake equipment, place the Rotair valve in Pass or Frt position, depending on the service required, place dead-engine cock in Live position, and close the double heading cock. Place automatic brake valve in Running position and independent brake valve in Release position.

## XIII. TOWING DEAD LOCOMOTIVE

A. To tow a locomotive dead in a train, the reverse lever should be removed to eliminate any likelihood of connecting the main power circuits, and the brakes should be set to operate like those in the train.



For 24-RL Equipment:

1. Close double heading cock.
2. Place automatic brake valve in Running position and independent brake valve in Release position and remove handles.
3. Place Rotair valve in Pass position.
4. Place dead-engine cock in Dead position.

For 6-SL Equipment:

1. Place double heading cock in Dead position.
2. Place both brake valves in Running position.
3. Open charging cock on the dead-engine feature.
4. If it is desired to keep the maximum braking power below standard, reduce the adjustment of the safety valve on the distributing valve so it opens at 25 lbs.

## XIV. MISCELLANEOUS OPERATIONS

A. Some items of equipment in the following operations are special modifications which are installed only when specified by purchaser.

1. Running through Water. If

necessary to operate through water, keep speed low enough to avoid splashing the motors, and avoid water more than 3" above the top of rail.

2. Operating over Cross-Overs. Reduce throttle at cross-overs to avoid excessive jarring of gears and electrical pitting of commutators.

3. Overspeed Control. Check the maximum recommended speed (about 65 mph). When a slightly higher speed is reached, the standard overspeed control initiates a service application of the air brakes. The diesel engines are automatically idled when such an application occurs. The engineer is first given a whistle warning, and a 6 second delay feature enables him to reduce speed and thus suppress the automatic application. The installation may be modified to give a whistel warning only, which leaves the control of power and brakes entirely to the judgment of the operator.

4. Recovery after Penalty, or Emergency Brake Application. Following any emergency, speed control, train control, deadman, or similar extra-ordinary brake application, move the throttle to the "off" position. In many instances, the interlocking is such that traction motors are automatically disconnected to avoid overloading them. However,



further interlocking prevents restoration of the electrical circuits until the throttle is in the "off" position. On 24-RL brake equipment place the automatic brake in Lap position until the brake system recovers.

## MULTIPLE UNIT OPERATION

Locomotives equipped for multiple unit operation may be handled as a single locomotive after connections are properly made. In addition to the conventional coupling of locomotives and air lines, electrical control circuits of the two locomotives must be connected. Jumpers for this purpose must be firmly plugged into the receptacles at the end of the locomotives. The controls are then set so that both the power and brakes are controlled from only one cab. The locomotive from which operation is controlled is called the leading unit, and any coupled locomotives are trailing units. Certain alarm and protective circuits, and certain auxiliary controls, such as sanding, are connected through the jumper, but the power plants and heavy duty circuits of the coupled units remain entirely independent of each other.

Multiple unit control of headlights is provided through a 4-position M.U. switch and two 3-position dimming switches at the operator's position. One dimming switch controls the front headlight and one the rear headlight, and each has an "off", "dim" and "full" position. The 4-position M.U. headlight switch must be properly set in all units, according to nameplate designations. The lighting breaker and dimming switch need be closed on the controlling unit only.





Connecting Units in Multiple

A. Couple the units together and connect the air lines and jumpers, making sure that each plug is pushed all the way into the receptacle and locked in place.

B. Open the cocks at the end of the air lines on both locomotives.

C. On the unit which will be controlling:

1. Make sure that the battery switch, fuel pump switch and control switch are closed.

2. Place the Rotair valve in Pass or Frt, depending on the service required.

3. Open the double heading cock.

4. Turn the unit selector switch to the proper setting for the number of units in multiple.

D. On trailing or non-controlling unit:

1. Close the double heading cock.

2. Place rotair valve in Pass Lap, or Frt Lap, depending on C-2 above.

3. Put the automatic brake in Running position, and remove handle.

4. Put the independent brake in Release position, and remove handle.

5. Put the throttle in the "idle" position and the transition selector in the "off" position.

6. Put the reverse lever in the "off" position, and remove handle.

7. Check that battery switch is closed.

8. Open the control switch and fuel pump switch.

E. Start the engines as previously outlined on page 7 . It will be necessary to start the engine in the trailing unit from the trailing cab. However, in the trailing unit leave the control switch open.

F. Close the generator field switch on the leading unit.

G. The locomotives may now be operated in the same manner as a single unit. The sander will apply sand to the front or rear of both trucks on both units as determined by the position of reverser.

Procedure for Changing Operating Cab

With the locomotive normally stopped (i.e., throttle in "idle", transition selector and reverser lever "off"):

A. In the cab which has been controlling:

1. Remove reverse lever.

2. Make at least a 20 lb. reduction with automatic brake valve.

3. Move automatic brake valve handle to Lap position and



independent brake to Release position.

4. Place double heading cock in Closed (cut-out) position.

5. Move K-2-A Rotair valve to Pass Lap, or Frt Lap, as required (or K-2 Rotair valve to Lap position).

6. Move automatic brake valve handle to Running position, and remove both the automatic and independent brake valve handles.

B. In the cab which will be controlling:

1. Put Rotair valve in Pass or Frt position, as required.

2. Move independent brake valve to full application position.

3. Open the double heading cock.

4. Close control switch and fuel pump switch.

5. Set the unit selector switch for the number of units in multiple.

6. Insert reverse lever.

C. Return to the former controlling cab:

1. Open control switch.

The units are now ready for multiple operation.

Connecting Units in Multiple

A. Couple the units together and connect the air lines and jumpers, making sure that each plug is pushed all the way into the receptacle and locked in place.

B. Open the cocks at the end of the air lines on both locomotives: throttle line, main reservoir line, equalizing pipe and brake pipe.

C. On trailing or non-controlling unit:

1. Place the double heading cock on the brake pedestal in Trailing position.

2. Remove the automatic brake valve handle (Lap position).

3. Remove the independent brake valve handle (Running position).

4. Check that the throttle is in the "idle" position.

5. Put the reverse lever in the "off" position and remove the handle.

6. Close the main battery switch in the equipment cabinet.

7. Open control switch.

8. Release the hand brake.

D. On the leading or controlling unit:

1. Turn the unit selector switch to



the proper setting for the number of units in multiple.

2. Close main battery switch.

3. Place double heading cock in the Lead position.

4. Close control switch and fuel pump switch.

E. Start the engines as previously outlined on page 7 . It will be necessary to start the engine in the trailing unit from the trailing cab. However, in the trailing unit, leave the control switch open.

F. Close the generator field switch on the leading unit.

G. The locomotives may now be operated in the same manner as a single unit. The sander will apply sand to the front or rear of both trucks on both units as determined by the position of reverser.

Procedure for Changing Operating Cab

With the locomotive normally stopped (i.e., throttle in "idle", transition selector and reverser lever "off"):

A. In the cab which has been controlling:

1. Remove reverse lever.

2. Make at least a 20 lb. reduction with automatic brake valve.

3. Place double heading cock in Trailing position.

4. Remove automatic brake valve handle (Lap position), and independent brake valve handle (Running position).

B. In the cab which will be controlling:

1. Insert brake valve handles. Move independent brake valve handle to Full Application position, and automatic brake valve handle to Running position.

2. Place double heading cock in Lead position.

3. Close control switch and fuel pump switch.

C. Return to the former controlling cab:

1. Open control switch and fuel pump switch.

The units are now ready for multiple operation.



## ALARMS AND PROTECTIVE DEVICES

Various protective devices ring an alarm bell and light warning lights when the equipment does not operate properly. The bell will ring on all units in multiple; the light will light only in the faulty unit. Operators should quickly recognize each of the following indications:

a. Low oil pressure in the engine lubricating system stops engine and rings the alarm bell.

b. If engine overheats, the water temperature switch lights the hot engine light and rings the bell. The engine, may or may not be automatically idled, according to specification. If not idled, the operator should reduce the load.

c. A ground relay will idle the engine, open the field contactors and give warning through an alarm or indicator light, if the high voltage power circuit becomes grounded. Sometimes a ground is temporary and the fault clears itself. Press the ground relay reset button in the cab to see whether normal operation can be resumed. If ground persists and it is necessary to pull into the clear or operate to a terminal point, open the ground relay cut-out switch.

A surge relay gives similar protection against flashover in the generator, and indication is received through the ground indications. However, the ground

relay cut-out switch will not restore emergency operation and necessary movements must be made with reduced loads to prevent further flashover.

d. Defective operation of the radiator fans will ring the bell and light the fan indication light. A fan reset button may be pressed to restore normal operation if the protective relay was tripped by a temporary voltage differential. No power or dynamic braking is obtainable when this relay is tripped.

e. Minor overloads in dynamic braking (especially if any unit in multiple tends to take more than its share of the load) are automatically reduced by a brake limiting relay and valve. Persistent overload will light the brake overload light and should be avoided by retarding the transition selector slightly.

f. A power knockout switch opens automatically when an emergency brake application is made by the brake valves. The generator fields and main power contactors are opened automatically to remove all load. The diesel engine will stop after fuel is exhausted in the fuel line, but the operator can return the throttle to idle and lap the brake valve to obtain a recovery before the engine stops. The fuel line may need priming if this is not done.



g. The field shunt failure light indicates defective field shunting equipment. All field shunting is automatically terminated, and the locomotive operates with normal full field. This protects rotating equipment from damage which may be incurred if loaded motors operate at slow speed with their fields shunted. The crew should report the condition to maintainers, but nothing need be done enroute, since only certain high speed performance is lost.

## DYNAMIC BRAKING

### GENERAL DESCRIPTION

Locomotives are sometimes equipped with a dynamic braking system in addition to the standard air braking equipment. Braking effort is controlled by the transition selector with the throttle in "idle". The energy involved in retarding the train by dynamic brakes is dissipated in the electrical equipment instead of in the brake shoes. At such times, the traction motors act as generators driven by the locomotive. This reduces wear and tear on brake shoes and, on long descending grades, eliminates delays which may otherwise be necessary for cooling wheels and shoes. Applications of the automatic brakes on the cars of a train are possible at all times, regardless of the setting of dynamic braking controls. However, the air system is interlocked with the electrical circuits so that it is impossible to make an automatic application of brakes on the locomotive during dynamic braking. Emergency applications may be made by the automatic brake at any time (although in some cases, a power knock-out device must first automatically interrupt the dynamic braking circuits).

### OPERATION

Dynamic braking will not function unless the dynamic braking cut-out switch is in dynamic braking position (closed), and it is generally left in that position. If the fan circuit is defective, the braking circuits are automatically kept inoperative. The usual braking procedure is summarized as follows:

1. Check to make sure the unit



selector switch is set to correspond with the number of units in service (as outlined on page 6).

2. Check that the reverse lever is in the direction in which the locomotive is moving, and place the throttle in "idle" position, and leave it there whenever braking dynamically.

3. Wait at least 10 seconds before moving the transition selector to the "off" position.

4. With transition selector in the "off" position, allow the slack to bunch if enough braking effort is developed. Allow sufficient time (about 10 seconds) for the automatic switches to establish braking circuits before expecting bunching action.

5. If necessary, move the transition selector to the first position in the braking range to complete the bunching of the train.

6. Braking effort is increased by moving the transition selector toward "full" position in the braking range.

7. Load ammeter reading should not exceed the braking limits given on the load limit nameplate. Do not permit the dynamic brake warning light to stay lit.

8. Additional braking effort may be applied at any time by the automatic brake valve.

9. To release the dynamic brake:

a. Move transition selector to the "off" position.

b. After a few seconds for the circuits to change over to motoring connections, set the transition selector in position "4" if operating alone, or in multiple with locomotives having automatic transition. If in multiple with a unit having manual transition, set the transition selector to the position required on that unit for the speed at which the train is traveling.

c. Apply power as desired if the train is to keep moving, or use the air brakes to come to a stop. Always adjust slack gradually.



## FUEL OIL SYSTEM

The fuel storage tank, tank filler and gauge are located at the rear of the locomotive. (Center tank is added on Model AS-616). Fill the tank slowly, observing level gauge to avoid overflow. Fuel oil is drawn through a suction strainer by a motor driven supply pump, and forced through a pressure filter into the fuel oil header, where it supplies the injection pumps. There is a gravity return line from the header to the tank.

A pressure relief valve limits fuel pressure in the header to 25 psi, by-passing excess fuel back to the tank. The supply pump is protected against pressure by a relief valve connected to its discharge. The suction strainer should be cleaned weekly; filter cartridges should be renewed as directed in the Maintenance Bulletin.

## GOVERNOR

A Woodward PG Governor responds to throttle settings to regulate engine speed, and also engine output through an added load control device. The circuits to the solenoids are fed through interlocks on the engine control relay, which when de-energized will retain the engine at idle speed regardless of throttle setting. This relay is de-energized if the engine control switch is in the "idle" or "off" position, or if the ground relay or wheel slip relays pick up. A shutdown solenoid in the governor stops the engine when the throttle is moved to its stop position, or when certain safety devices function.

ENGINE OVERSPEED CONTROL

The engine is prevented from exceeding a specific safe rpm through action of an overspeed stop. This appliance, situated on the front of the camshaft casing at the generator end of the engine, is a spring loaded tripping device, set to trip at a predetermined camshaft speed. The tripping operation actuates a plunger which moves the fuel control shaft to the no-fuel position and stops the engine. Before starting the engine again, the overspeed stop must be reset.

## LUBRICATING OIL SYSTEM

The lubricating oil is drawn from the sump, formed by the bedplate of the engine, through a suction strainer by the engine driven pump. The pump forces the oil through an oil filter, a metal edge type strainer, and a heat exchanger. The oil is then delivered to the engine header, which distributes the oil to all parts of engine requiring lubrication.

MAINTENANCE

The oil level in the sump should be checked daily and must be maintained above the "low" mark. The handle on the metal edge type strainer must be rotated every day.

To fill the crankcase, pour the proper type of oil through the filler pipe. Fill to the "full" mark on the bayonet gauge. To drain oil from the engine, open the drain valve and remove the plugs from the bottom of the camshaft trough. Drain the oil into a suitable container. Also, be sure to drain the strainers, the filter and the heat



exchanger, when changing crankcase oil.

Refer to Maintenance Bulletin for lube oil filter maintenance instructions.

LUBE OIL PRESSURE

The pressure gauge in the cab should read between 50 lbs. and 55 lbs. (This is equivalent to 65 lbs. at the header). The governor automatically shuts down the engine if the pressure drops too low. A switch in the governor closes at such times to close the alarm circuits. The bells ring in all units connected in multiple.

## COOLING WATER SYSTEM

Water is circulated through the engine, heat exchanger and cooling radiator by an engine driven pump. An expansion tank vented to the atmosphere through an overflow pipe acts as a reservoir for maintaining a full system. The water level in the expansion tank must be maintained above the "low" mark on the gauge. Check every 8 hours.

To fill the system, add water through the connection located over No. 1 truck on right side of the locomotive. Run water until water spills through the overflow pipe. The system can be filled through the filler on the roof near the front, but it is not recommended because of the danger of trapping air in the system. If the engine overheats because of low water level, idle the engine and add hot water if possible. If it is necessary to use cold water, it should be added very slowly.

If the locomotive is to be left standing exposed to freezing temperature, it will be necessary to drain the cooling system, or

use an outside source of steam to prevent freezing. If a steam source is available, connect it to the drain pipe through a check valve so that the water cannot back up into the steam line. Open the drain valve enough to allow steam to enter the system. To drain the system, open the drain valve. Drain heat exchanger and turbocharger also.

TEMPERATURE CONTROL

Water temperature in the engine cooling system is normally regulated automatically by keeping the fan control switch in "auto" position. As water temperature rises and falls, the speed of the fans is regulated by a temperature switch which determines the fan speed.

If the automatic system does not function properly, throw the fan switch to the manual (on) position.

WATER TEMPERATURE SWITCH

A water temperature switch automatically closes when engine water temperature becomes excessive. This rings the alarm bell and lights the hot engine indicator light. If two units are connected in multiple, the bells function on both units.



## AIR SYSTEM

Air, pumped by an engine driven compressor into reservoirs, is used in the actuation of all pneumatic equipment, including sanders, air horn, window wipers, locomotive brakes and train brakes. In multiple operation, the air system of coupled units combine to form a single system.

AIR COMPRESSOR

The air compressor is a two-stage type, in which the low pressure cylinders pump air through an inter-cooler to the high pressure cylinder. Air is pumped into lines leading to the main reservoir by the high pressure cylinder. An air compressor governor, connected to the main reservoir, controls the compressor, which operates whenever the diesel engine runs. A governor cut-out is set to prevent a main reservoir pressure in excess of 140 psi, and to resume pumping when pressure drops to 125 psi. The compressors of units connected in multiple operate in unison whenever pumping is resumed.

PNEUMATIC CONTROLS

Air for the pneumatic controls is supplied at a pressure of 70 psi from the main reservoir through a reducing valve. Equipment includes the reverser, power switches, and also the cam switch on dynamically braked locomotives.

## ELECTRICAL SYSTEM

An electrical drive is the most practical means of transmitting diesel engine power to the driving wheels, and electro-pneumatic controls provide the simplest means of handling both the propulsion motors and the auxiliary equipment. Normal operations are controlled by a throttle, a reverser lever, and a standard braking system. After the manually operated switches are set for normal operation, and the engine started as previously described, power is controlled by the throttle. Engine cooling is controlled automatically.

Operating men should have some fundamental knowledge of the electrical system. They are then more competent to handle the controls, watch indicating instruments for prevention of trouble, and meet non-routine operating conditions when they arise.

Most of the instruments and routine controls are mounted on panels in front of the engineer. There is high voltage on much of this equipment, and no attempt should be made to enter the cabinet without taking proper safety precautions.

The main generator supplies high voltage power to the traction motors and fan motors. The auxiliary generator charges the battery and supplies low voltage power (about 75 volts) to the lighting and control circuits and the 4-pole exciter field circuit. When more than one diesel engine is controlled from one controller, the only electrical connections between units are low voltage control circuits.

The principal types of control equipment



function as follows:

Relays - A relay is a coil which opens or closes a set of comparatively light-duty contacts (generally in a controlling circuit). The coil may be in either the high or low voltage circuit and may be adjusted to pick-up or drop-out at various voltages, and calibrated to respond to varying operating conditions. As the name implies, it relays an impulse to other equipment (mostly contactors), and more than one contactor may be controlled by a single relay.

A ground relay will idle the engine, open the field contactors, and give warning through an alarm or indicator light if the high voltage power circuit becomes grounded. Sometimes a ground is temporary and the fault clears itself. Press the ground relay reset button in the cab to see whether normal operation can be resumed. If ground persists, and it is necessary to pull into the clear or operate to a terminal point, open the ground relay cut-out switch.

Contactors - A contactor is a coil-operated set of contacts (generally heavy duty, and in the circuit being controlled). Its closed or open positions generally depend on whether it is energized or de-energized. There is usually no adjustment for intermediate voltages or currents, because the more sensitive relays are used for such purposes. Light-duty contacts on a contactor are called interlocks, which are described in the next paragraph.

Interlocks - An interlock is an auxiliary switch mounted on, and controlled by, another switch, contactor, valve or similar control equipment. It is operated

by a cam or mechanical linkage which is so connected that the opening and closing of the auxiliary circuit is dependent on the operation of equipment in the main circuit. They are used to control the sequence of operation, or to permit making or breaking related circuits only when proper conditions exist. The chief concern to the operator is that sluggish or faulty interlocking can cause faulty locomotive operation.

Electro-Pneumatic Valve - An electro-pneumatic valve (or magnet valve) consists of an electrical coil in a controlling circuit which controls valves for the pneumatic operation of certain equipment. For example, the reverser and the power switches are pneumatically operated by a valve which is built into the equipment. Control air pressure is maintained from the main air reservoir, but at a lower pressure.

Breaker-Type Switch - Some manually operated switches open automatically when overloaded, and should be checked if the circuits involved are not functioning. They must be moved to full "off" position before being reclosed. The following breakers should be checked if their circuits are faulty:

Auxiliary Generator Breaker in the equipment cabinet. The auxiliary generator will not supply power to the control circuits or the battery. The battery will discharge to feed the control circuits.

Auxiliary Generator Field Breaker must be closed to connect the auxiliary generator field, and load regulator, to the low voltage circuits.



Generator Field Breaker must be closed to energize the main generator field contactors, and train-line wire GF.

Fan Motor Breaker in the equipment cabinet. The fans will stop.

Single Pole Breakers connect the control, lighting, fuel pump and the ground realy cut-out circuits.

Nameplates identify these respective switches.

Battery Protection - A reverse current relay protects the battery against discharge through an idle or defective auxiliary generator. The relay opens a contactor in the circuits whenever a reverse current flows. This contactor closes automatically any time auxiliary generator voltage exceeds battery voltage.

## OPERATING DIFFICULTIES AND CAUSES

I. ENGINE DOES NOT TURN WHEN STARTING BUTTON IS PRESSED

A. Battery switch open.
B. Control switch open.

II. ENGINE TURNS BUT DOES NOT FIRE, OR CONTINUE RUNNING AFTER RELEASING THE STARTING BUTTON

A. Fuel tank empty.
B. Fuel pump switch open.
C. Emergency fuel cut-out valve is tripped.
D. Overspeed stop has been tripped. Reset.
E. Low fuel oil pressure.
F. Insufficient oil supply in the governor.

III. ENGINE DOES NOT RESPOND TO THROTTLE SETTING

A. Engine control switch in the "idle" position.
B. Ground relay closed.

IV. LOCOMOTIVE DOES NOT MOVE

A. Reverser not in the "forward" or "reverse" position.
B. Transition lever in the "off" position.
C. Auxiliary generator switch open.
D. Generator field switch open.
E. Traction motors cut out.
F. Hand brake still set.
G. Starting contactors stuck in Closed position.



V. ENGINE STOPS

A. Overspeed stop has tripped. Reset. Notify maintainer if it continues to trip.
B. Low lubricating oil pressure, causing governor to shut down the engine.
C. Emergency fuel cut-out valve has been tripped. Reset.
D. Fuel tank empty.
E. Engine control switch in the "off" position.
F. Open breaker in fuel pump motor circuit.

VI. LOW FUEL OIL PRESSURE

A. Fuel tank empty.
B. Emergency fuel cut-out valve tripped. Reset.
C. Sticking relief valves. Try tapping them.
D. Faulty pump.
E. Fuel pump stopped.

VII. LOW LUBRICATING OIL PRESSURE

A. Low oil level.
B. Clogged pressure strainer. Turn the handle on top of the strainer two revolutions in the clockwise direction.
C. Sticking relief valves. Try tapping them.
D. Hot or diluted oil.

VIII. ENGINE OVERHEATS

A. Low water level.
B. Breaker open. (Fan motor circuit).
C. Radiator fans not functioning properly.

IX. AIR PRESSURE TOO HIGH OR TOO LOW

A. Compressor governor cut-out cock closed.
B. Compressor governor sticking. Try tapping it.

X. BATTERY AMMETER SHOWS DISCHARGE (ENGINE RUNNING)

A. Auxiliary generator switch open.
B. Faulty battery contactor or relay.



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